STATIC COMPUTER MEMORY INTEGRITY TESTING (SCMIT)
An experiment flown on STS-40 as part of GAS Payload G-616

Thomas Hancock
Private Research
Huntsville, AL USA

ABSTRACT

This experiment investigated the integrity of static computer memory (floppy disk media) when exposed to the environment of low earth orbit. The experiment attempted to record soft-event upsets (bit-flips) in static computer memory. Typical conditions that exist in low earth orbit that may cause soft-event upsets include: cosmic rays, low level background radiation, charged fields, static charges and the earth's magnetic field. Over the years several spacecraft have been affected by soft-event upsets (bit-flips), and these events have caused a loss of data or affected spacecraft guidance and control.

This paper will also describe a commercial spin-off that is being developed from the experiment.

INTRODUCTION

Over the years several different spacecraft have suffered soft event upsets (bit-flips) of their onboard memory. The most famous instance occurred in 1986 when the Voyager 2 spacecraft was encountering the planet Uranus. The spacecraft suffered soft-event upsets in its Flight Data Subsystem that caused a loss of guidance and control for several hours and resulted in the spacecraft pointing its cameras and other instruments out into deep space and away from the planet.

Today as larger, more complicated systems are planned (United States Space Station Freedom, etc.) the possibility of soft-event upsets may become more of a concern. Large space systems may not rely on mass uplinks (for reloading of their command and data, attitude control and experiment work station subsystems) due to the size and complexity of the uplink files, but carry back-ups of the flight software (operating systems) onboard as static memory.

Goal

The goal of this experiment was to:

1. Observe soft-event upsets
2. Determine the frequency of soft-event upsets
3. Determine the characteristics of soft-event upsets
4. Determine the possible effectiveness of different types of shielding material
5. Evaluate the possibility of using static memory as a type of Passive detector.

EXPERIMENT

Methods and Materials

The experiment consisted of 40 floppy disks of a standard commercial type. Each contained a text file that functioned as a bit-map. Each text file/bit-map was of an identical size and format (see Figure 1). This method made it simple to determine when a soft-event upset had occurred by observing a change in the logic state (the character representation) of any area on the bit map during post flight analysis (see Figure 3). Each text file filled the disk to capacity.

Groups of 10 disks were inserted into each of four storage containers. Several of the disks were covered in one of three types of shielding material. The three types of shielding material were:

normal anti-static nylon
aluminized mylar mesh
field dispersing (electrically neutral) nylon.

Procedure

The experiment was constructed by:

1. Developing a large text file/bit-maps
2. Copying identical bit-maps on all 40 disks
3. Covering a number of the disks with one of 3 types of shielding material
4. Testing to assure the integrity of the disks
5. Inserting disks in groups of 10 into storage boxes

The experiment was integrated into the GAS canister in July of 1990. The experiment was stored in the GAS canister on the GAS bridge until early 1991 and was launched in June 1991 as part of STS-40. The experiment remained in orbit for 9 days.

Post flight recovery of the experiment took place in July of 1991 and detailed analysis was started shortly thereafter.

Post Flight Analysis

Each disk was analyzed for evidence of soft-event upset. Currently single event, soft-event upsets have not been observed. However, 10 disks did exhibit characteristics that may or may not be attributable to massive numbers of soft-event upsets. As each disk was verified prior to launch, errors of the type observed normally would have been detected during testing. Unfortunately the experiment lacks the fidelity to accurately measure massive changes to the logic state at this time, as these were not anticipated prior to flight. The disks that exhibited these characteristic were not shielded during the flight.

CONCLUSIONS

In general, the experiment was successful. The type of soft-event upset (single events) anticipated prior to flight were not observed. However, a massive number of changes observed in the logic state of 10 disks does indicate the possibility that events had occurred and were recorded on the disk media. The experiment should be repeated with a greater level of fidelity and if possible, flown several times to establish a baseline.

COMMERCIAL SPIN-OFF

INTRODUCTION

During the development of this experiment, a new method for measuring levels of exposure to or detecting numbers of events (bit-flips) caused by radiation, cosmic rays or other energetic sources was identified. This product uses a method similar to that employed in the experiment.

Methods and Materials

This product will use standard size 3.5 inch floppy disks. Each disk will have its magnetic media made of a material that is more susceptible to soft-event upsets (see Figure 2). Each disk will contain a standard text file/bit-map (similar to Figure 1.).

Procedure

A user can carry the disk(s) or place them within the environment that is to be monitored. This product also has a potential use as a static detection array. Several disks can be placed on the surface of a small retrievable satellite or other structure for long term monitoring of the associated environment (earth or space).

When desired, the dosage or number of events recorded can be determined by using a standard statistical algorithm. This method makes it possible for a user to determine the relative dosage or number of events recorded by inserting the disk into any standard Personnel Computer and starting the associated program.

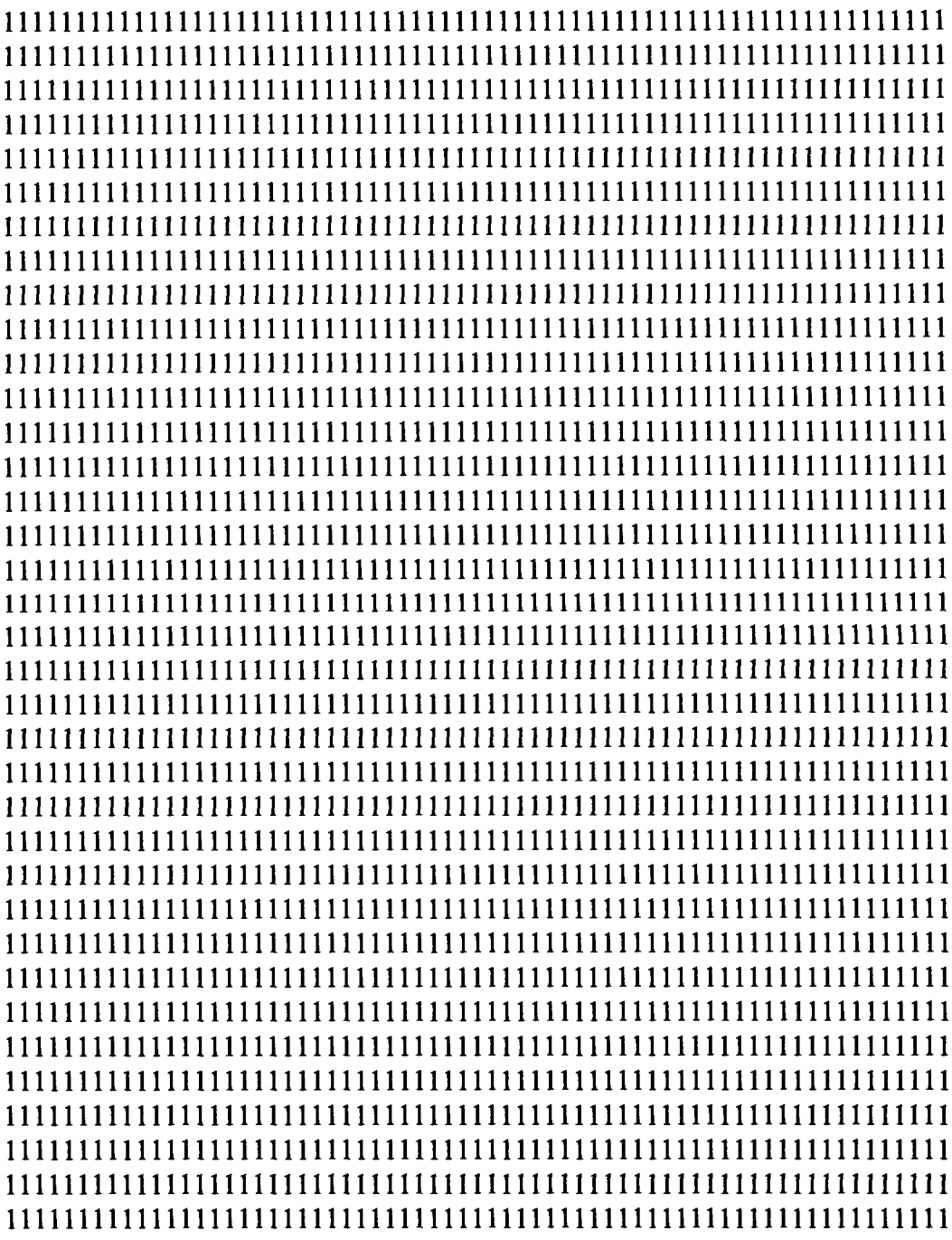

Figure 1. Sample of Text File/ Bit-map

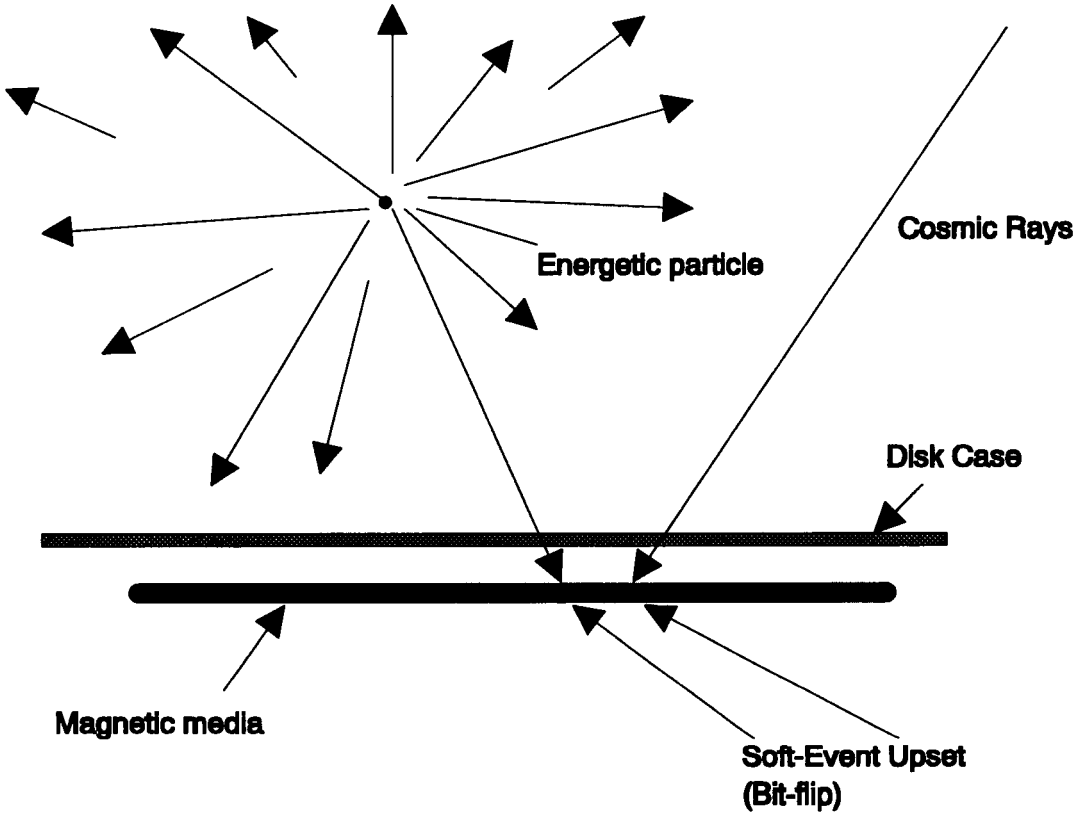

Figure 2. Soft-Event Upset

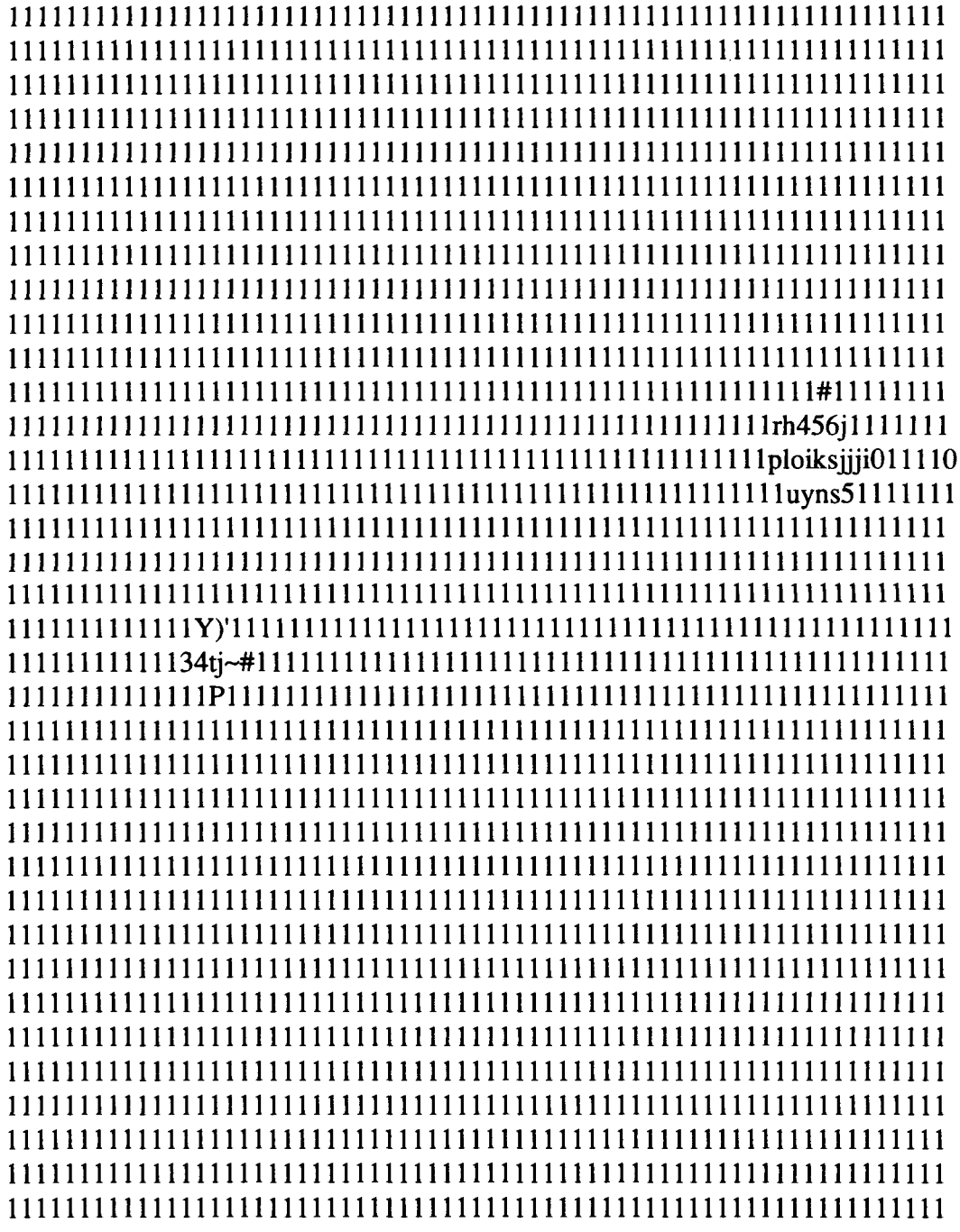

Figure 3. Example of soft-event upsets anticipated before flight